Research on the extension of *Tamarix* shrubs resulted from development projects in arid area

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Abstract: *Tamarix* plant is widely distributed in the arid areas of China for its great tolerance of draught, salt and alkali and attracts more attention by its strong capacity in windbreak and sand-fixations. "*Tamarix* dunes" constitute special desert bio-landscape in arid area. During last several decades, *Tamarix* shrubs declined and "*Tamarix* dunes" were also severely destroyed due to the land exploitation and serious deforestation, etc. From the 1980s until now, the extending phenomenon of *Tamarix* shrubs caused by developmental projects such as building highway, railway was studied in the western dry area of China, including western section of Hexi Corridor of Gansu, railroads and highways around the two greatest basin in Xinjiang and interior regions in Gurbantonggut desert, through on-the-spot survey along the transportation lines and setting up sampling plots along the roads. It was found that large quantities of *Tamarix* plants grow in the catchment area of low-lying lands that were formed by bulldozer operation during road building period. The extension of *Tamarix* shrubs caused by engineering was similar to that of the other section of the area to some extent, but went beyond the original distribution. This extension is beneficial to the ecological restoration and re-vegetation of western region of China and plays an important role in control of the sandstorms and improvement of ecological environments. As a result, it is necessary to make a further study on the extending phenomenon of *Tamarix* shrubs and to seek approach to promote wider extension of *Tamarix* shrubs in suitable habitats.

Key words: Arid area; *Tamarix*; Development engineering; Vegetation extension

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Introduction

In arid area, the notable characteristics of natural vegetation are sparse and low for it rains rarely (Aleson 1959). As a result, vegetation has extremely weak ability to protect these habitats (Huang 1999a), once interferences take place, the rare vegetation is destroyed easily and habitats are put in a rigorous situation. Since the 1950s, with increase of human activities, such as reclaiming wasteland, chopping and over herding, sparse deserta have become worsen (Sun 1991). In the same way, natural habitats, with the exception of oasis, also have generally deteriorated, the area of rivers and lakes has reduced, even some lakes have dried up, plants resources have rapidly lessen, three greatest formations respectively composed of dominant *Haloxylon ammodendron*, *Tamarix* and *Populus euphratica* also have generally degenerated (Zhang 1991), some fixing dunes have got back to activation again (Xia 1991), railroads, highways and farm fields have been confronted with quicksand. In order to suppress quicksand and improve ecological environments, a large quantity of research and treatment have done to desert, but the achievements are far away from human's purpose due to dry climate, lack of water and outmoded technology in arid area. By the traditionally afforesting measures, it is difficult to carry out building ecological environments and put ecological restoration into practice under no irrigation water and dry climate condition. Therefore in arid area, vegetation restoration is only by "enclosement" or at the mercy of nature (Qian 2003). So far, annual reports of environmental conditions have always been "partial improvement but overall situation being worsen". The explanations of the phenomenon are that it is not realistic to restore and rebuild large area vegetation only taking orders from the natural conditions.

In fact, certain natural laws are followed in the process of reproduction and growth of deserta (Huang 1999b, 2002). Not knowing the laws, Man is put in passive situation. Therefore, finding these laws and putting them into effect is helpful to turning the passive position into positive situation. As far as the process of developing arid area is concerned, the degeneration of vegetation and ecological environments result from developmental engineering, but it is strange to find that *Tamarix* shrubs are extending widely in engineering area. Obviously, the extension is close related to the process of engineering. The above phenomenon is further analyzed in this paper in order to find alternative methods to restore vegetation and build ecological environments.

Study area and environments

The range of research is in western dry area of china, including western section of Hexi Corridor of Gansu, rail-

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roads and highways around the two greatest basin in Xinjiang and interior regions in Gurbantonggut desert.

This area is hot in summer and cold in winter, and average annual precipitation is below 150 mm (Geng 1986). In most parts of Junngar basin, precipitation is rough 100-160 mm but the south of Tianshan is not included. In the south of Tianshan, the east of Xinjiang and the west of Hexi Corridor, the average annual precipitation is only 30-50 mm.

The research was carried out from the 1980s until now. An on-the-spot survey along the transportation lines was made in the study area. Measurement and sampling were conducted by setting up plots along the road between Urumqi and Koala and main lines of its extension, the eastern road between Urumqi and Aletai, and in the northern desert of 150-Farm (Huang 1983; Huang and Yao 1988). In the meantime, sowing experiments were made in Mosowan (Yao and Huang 1999, 1998)

Results

There is extremely sparse vegetation in most places of research, but dense shrubs in some special places. For example, the vegetation coverage is below 2% in the land sections that are more than 20 m away from both sides of the roads and not impacted by engineering. Some low-lying lands, close to the roadbed, were formed when bulldozer work for building roads and dived into many spaces by long and narrow moulds. These spaces, like rice fields enclosed by banks, become catchment areas after rains. Only in such catchment areas, can *Tamarix* seeds germinate and can seedlings grow. Occasionally it was found that *Tamarix* shrubs were distributed as long as a few kilometers on both sides of main lines. As for newly built road section of the eastern road between Urumuqi and Aletai, there is no vegetation at section with a slope of 5 Km in length near the Wucaiwan where the yellow soil is uncovered, but in the low-lying lands, along the two sides of the road section that is roughly 10km long, there is either thick or sparse vegetation in which *Tamrix spp.* is dominant species. Selective measurement of the dense *Tamrix* shrubs showed that the average height of the shrubs was 2.1 m and the highest is 4 m. The average coverage of the shrubs was about 50%, the extreme low and highest coverage was 10% and 70% respectively and average dense was rough 1798 stubs/hm^2.

It was observed that a large quantities of *Tamarix* shrubs occurred in the low-lying lands along the road between Luntai and Sanchakou (Huang 1983), and the shrubs were mostly distributed around the catchmental pits formed by bulldozer operation, but no shrubs was found in the pits due to the fact that thick silt layer occurs in pits. For the pits with water accumulation, *Tamarix* shrubs were usually distributed along the water line lof impoundment. When the pits were nearly filled up with silt layer, Tamarix seedlings could grow in the middle of these pits, but seedlings in pits was younger than that around pits, which proves that growth of the plants is different in different habitats, especially in age (Huang 1983).

Tamarix. shrubs were distributed widely in low-lying lands on both sides of the road between Korla and Tkalamankan desert because of wet site, with an average coverage of 70%. Except *Tamarix* spp. there were also many other shrub species such as*Halostachya caspica, Halocnemum strobilaceum, Phragmites communis, Halimodendron halodendron, Karelinia caspica* distributed here. *Tamarix* shrubs were also found in low-lying lands along the railway between Hami and Jiuquan. In addition, on the gentle lands, not impacted by engineering,there exists sparse and short *Nitraria* spp., especially in the vicinity of Yumen.

In 150-Farm that lies in the south of Gurbantonggut desert or in the tip of Mosowan oasis stretching 60km to desert interior (Huang and Yao 1988), we first found *Tamarix* seedlings at the place of 10 km stretching northwesterly from the edge of the oasis in the 1980's. The explanations of the phenomenon are that catchment areas are formed on the surface of takir covered with thin sand soil, *Tamarix* seeds can germinate and seedlings can grow depending on the collected water. The statistics of abound data showed, the depth of sand soil on the surface of takir was interrelated with the water content of takir surface.*Tamarix* seedlings had a highest survival rate at the site condition with sand soil of 10-20 cm in depth, where the available water holding capacity was also highest. Therefore, the distributions of *Tamarix* seedlings are suffered to limitation of the depth of sand soil on the surface of takir.

Analysis and discussion

Ecological position of *Tamarix* spp. in arid area

Tamarix spp., *Haloxylon ammodendron* and *Populus euphratica* that are all constructive species, respectively constitutes three greatest formations of deserta in Xinjiang. *Haloxylon ammodendron* is distributed most widely in Xinjiang desert, and the area of its distribution amounts to 7 500 000 hm^2 and accounts for 68% of the total area of distribution in China (the data from synthetic inquisition of 1950's in Xinjiang) (Hu 1962); The area of *Tamarix* shrubs amounts to 5 340 000 hm^2, mainly distributing in the southern areas of Xinjiang and dispersively in other areas (Liu 1995); The area of *Populus euphratica* woods is 540 000 hm^2 in Xinjiang (Qin 1959). In Xinjiang, the three greatest deserta formations have important ecological value in keeping desert habitats stable, but deserta has seriously declined with strong destructive activities.

Tamarix shrubs are usually encountered on banks of rivers and lakes, around mountain springs, in valleys and arid desert, sometimes in the top of the dunes. Occasionally, *Tamarix* plants are associated with *Populus euphratica* shrubs and *Haloxyleon ammodendron* shrubs. In arid desert, the most attractive is "*Tamarix* dunes ". Many "*Tamarix* dunes" become a special landscape. What's more, most "*Tamarix* dunes " distributed in quicksand region have the

great capacity of breaking wind and fixing sand. In fact, the capacity of *Tamarix* plants is mightiest among the desert plants. The length of dedicate branches is positively related with the intense of accumulated sand, that is to say, "shrubs rise with dunes' expanding" or shrubs live on the top of dunes forever. The landscape may be seen in Junngar basin and Takalamankan desert. In addition, a number of small sand mounds, like convex lens, are formed at the center of the stems under the scatted *Tamarix* shrubs including young plants. The central points of the mounds is 50-70 cm high, diameter of the mounds is 1-3 m. It is general to take shape into mounds depending on shrubs in desert. With the exception of *Tamarix* shrubs, the sand mounds of *Nitraia* spp. and *Aristida* spp. is below 50 cm high and diameter is less than 1 m. Generally, the sand mounds can not be formed by the stem base of *Haloxyleon ammodendron* shrubs.However, when a plenty of branches of *Haloxyleon ammodendron* creeping on the ground a 70cm sand mound with inner diameterof less than 1 m could be formed. Even so, comparing with *Tamarix* shrubs, the scale of accumulated sand and sand-fixing function of these plants is negligible. "*Tamarix* dune "is extremely stable because it is usually formed by mixing large quantity of deadwood and fallen leaves with sand. Besides, putrefied deadwood and fallen leaves can be used as organic fertilizer. Even though in even desert, scatted "*Tamarix* dunes " result in different habitats, and other plants invade into *Tamarix* shrubs, thus increasingthe diversity of plants and vegetation coverage and decreasing the frequencies of sandstorm.

Natural distribution patterns of *Tamarix shrubs*

Tamarix shrubs are distributed widely on the banks of rivers including old riverbeds, in valleys, on the brink of swamps and in various landforms, even on the top of all kinds of dunes, but the coverage of the *Tamarix* shrubs in dunes is far less than on the banks of dry rivers and on the brink of swamps. The habitats of the same *Tamarix* are diverse too. Take *Tamarix romosissima* for example, it can be found on the banks of rivers, on the brink of swamps and lakes, in valleys, in desert and dunes. This shows that *Tamarix* plants have widely ecological amplitude and extremely strong adaptability. At the same time, distribution of *Tamarix* plants is obviously limited of space in arid area. In regard to the two great basins in Xinjiang, the number of *Tamarix* shrubs in the south is larger than in the north of Xinjiang. Moreover, most *Tamarix* shrubs are densely distributed around the rivers and lakes, but rare in others.

Previous research showed (Huang and Yao 1988) that distribution of surface water had evident influence on the patterns of *Tamarix* shrubs. Investigation demonstrated: germination of *Tamarix* seeds was istrongly dependent on the surface water. In flooded area, such as beaches, the banks of rivers, the brink of lakes and swamps, and the catchmental points that are able to keep moist for long period time, *Tamarix* shrubs are densely distributed. There is no seedling in dry riverbeds. The phenomenon is explained that the over-wet surface is beneficial to seeds germination and seedlings growth. In the moist beaches after flooded, there exists a large number of seedlings, as is seen in the downstream course of Black river where there has been no water for many years. There being no rivers and surface runoffs in the regions (Tang 1992), such as Gurbantongut desert, the valleys between dunes in Taklamakan desert and etc, accumulated surface water on a small scale or short-term catchment after rains is only advantageous to *Tamarix* seeds germination and seedlings growth. Whereas, the fact that *Tamarix* plants emerge in the catchment areas on both sides of railways and roads proves that *Tamarix* seeds can germinate and seedlings can smoothly grow in catchment areas with no surface runoffs.

Where there is no runoff and annual precipitation is below 150 mm (Tang 1992), the only water sources is local precipitation, but it is not enough for deserta to grow. Differentially, accumulated surface water in natural landforms plays an important role in seeds germinating and seedlings growing. Thus, the patterns of the *Tamarix* shrubs in desert are up to the distribution of the catchment areas. For example, we found the large number of *Tamarix* seedlings in some sites in Gurbantongut desert (Huang and Yao 1988) It proves that redistribution of surface water in space does not only provides seeds and seedlings with enough water, but also improves soil structures (Huang 1983, 1988; Huang and Yao 1988). So it is possible for *Tamarix* seedlings to survival. Similarly, *Tamarix* shrubs grow in engineering area. Eventually, the number of *Tamarix* shrubs along the main transportation lines is similar to the forest belt on both sides of roads and railroads.

According to the data: the habitats of *Tamarix* seeds germination and seedlings growth differ greatly from that of adult plants. It is truth that all seedlings survive in the moist environments.In addition, the anatomical characteristics of seedlings are nydra. Eventually, it is necessary for seedlings to transit successfully from nydra structure to aexoarid structure. Moreover, the period of the transition is as short as possible. As has been tested in field (Lan 1991), seedlings can keep life in gradually drying habitats if the speed of roots growth in length is much faster than the change of wilting percentage of surface soil. So long as seedlings are of perfect structures, the adaptability to arid of seedlings is similar to that of the adult plants.

In fact, some *Tamarix* plants live in damp soil for a long period time, but most adult plants are found in comparative dry habitats, especially on the top of the "*Tamarix* dunes". They only make use of natural precipitation to keep life under the condition that the underground water is not available to them. *Tamarix* plants generally complete their life cycle under moist conditions, which is a common characteristic of *Tamarix* plants in different habitats (Huang 2002). The plant has so strong adaptability in arid area that it is considered as one of ideal species in the process of

building ecological environments. If seedlings are artificially provided with enough water to help complete smoothly structural transition, the plant can depend on natural precipitation to survive by itself.

Thoughts of natural extension of *Tamarix* shrubs in engineering areas

In the past, there being no surface runoffs in arid area, low and sparse xerophytes are originally rare in desert, even no vegetation. However, at present, with the effects of developmental engineering, engineering areas are home to numerous desert plants. We found that large quantities of *Tamarix* plants live in catchment area of low-lying lands, but none in others. Even if in catchment areas, there are no shrubs without dispersal seeds of *Tamarix* plants. It is objective that there is little precipitation and less catchmental chances (Geng 1986). Besides, the water-holding capacity of soil depends on the soil structures in a degree. Surface soil moisture content is high in catchment areas with only fine sand and clay soil. Otherwise, surface water infiltrates totally into underground. Therefore, to improve artificially soil structures is helpful to decrease infiltration and strengthen the available water-holding capacity of soil. Whereas, in some regions without dispersal seeds, artificially introduced seeds contributes to effective extension of *Tamarix* shrubs in low-lying lands. On account of limit manpower, shortage of water resource as well as barren soil in arid area, building ecological environments should suit measures to local conditions, the measure is one of the new methods of building ecological environments in arid area.

Natural extension of indigenous species in catchment areas indicates that it is possible to successfully build ecological environments under no irrigational condition in arid area. (Of course, building ecological environments mainly refers to restore and rebuild vegetation here.) Meanwhile, the natural extension of deserta provides theorem and technological foundation for completely improving habitats and restoring deserta (Huang 1999a 1999b, 2002)..

Conclusions

Tamarix shrubs in engineering area quickly extend for the reason that the redistribution of water from precipitation resulting from changed topographies is beneficial to seed germination and seedlings growth.

The extension of *Tamarix* shrubs in no runoff regions is related with its strong adaptability to dry environments. Indigenous plants that are of strong adaptability should be used for restoring and rebuilding deserta, which contributes to smoothly building ecological environments in arid area.

Artificially setting up microhabitats, improving soil structures, and introducing plants species of strong adaptability play an important role in building ecological environments, especially in restoring and rebuilding deserta under no irrigational water in arid area.

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